John B. King

From: Stephen Lee <Stephen.Lee@la.gov>
Sent: Thursday, December 2, 2021 12:54 PM
To: Jonathan Rice
Subject: PRR 11-30-2021 John B. King- EPA correspondence regarding Hall Plots

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From: Kellie McNamara <Kellie.McNamara@LA.GOV>
Sent: Wednesday, December 1, 2021 5:05 PM
To: Stephen Lee <Stephen.Lee@la.gov>
Subject: FW: Hall Plots

Here is the response from Matthew Liu with EPA R6.

Kellie McNamara, PE
Engineering Manager
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Injection & Mining Division
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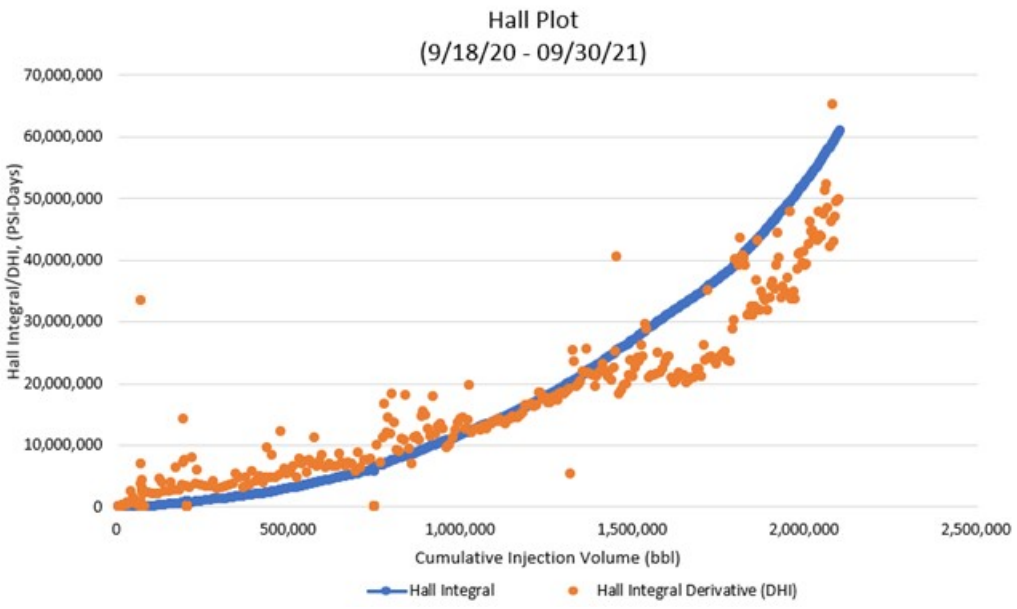
From: Liu, Matthew <Liu.Matthew@epa.gov>
Sent: Monday, November 8, 2021 9:30 AM
To: Kellie McNamara <Kellie.McNamara@LA.GOV>
Cc: Jeffery Miller <Jeffery.Miller@LA.GOV>; Katie Robinson <Katie.Robinson@LA.GOV>
Subject: Re: Hall Plots

Hello Kellie,

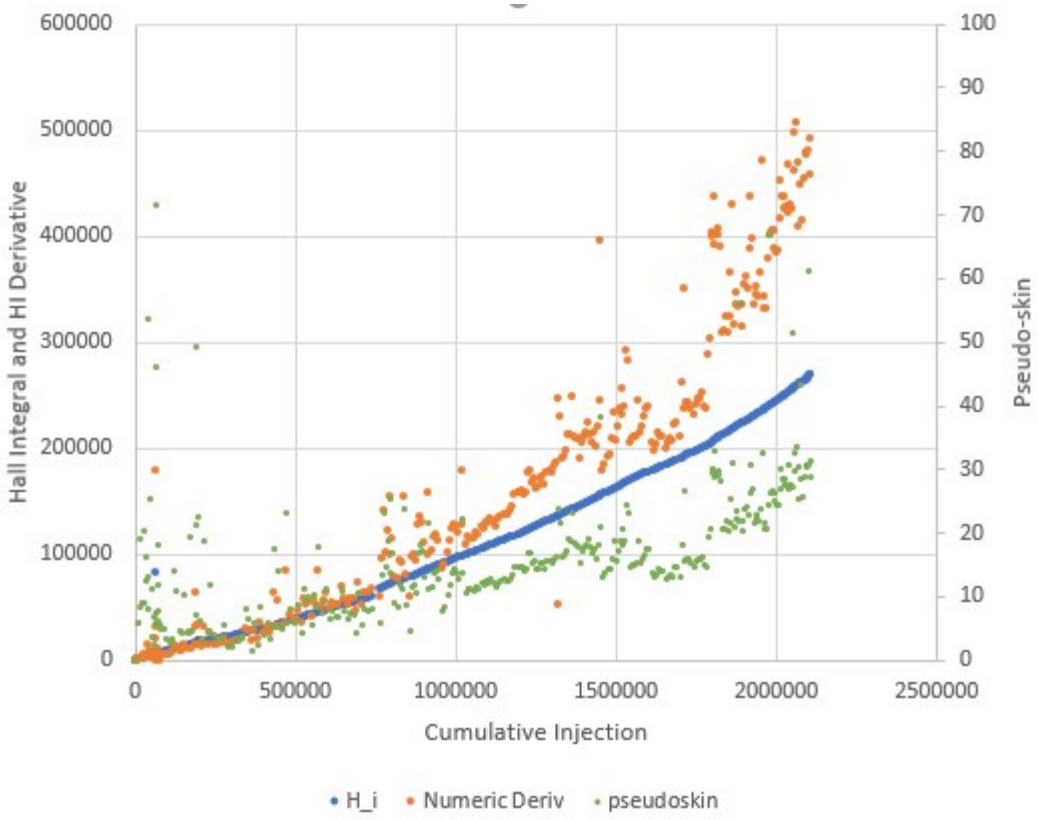
I've read through the documents that you sent me and looked around the Hall plot spreadsheet. In the spreadsheet, I found a couple errors that complicate things. The Hall plot that you provided shows radial flow, followed by a period of increased injectivity (potentially a fracture), and then another period of radial flow.



However, the first issue was the calculation of the Hall Integral, as the timestep used in the integration was linearly increasing with time. This promotes the concave up trend seen in the Hall integral plot. When the integration is corrected, the Hall plot still has a slight concave up trend. The second issue was the calculation of the derivative. The equation that is used in the literature is:

$$D_{Hn} = \frac{\mathrm{d}\int(p_{wf} - p_e)dt}{\mathrm{d}\ln(W_i)} \cong \frac{{I_H}^{n+1} - {I_H}^{n}}{\ln(W_i)^{n+1} - \ln(W_i)^{n}}$$

When the Hall integral and the derivative calculations are corrected, the Hall integral and the Derivative curve are comparable in scale, as shown below. In this case, it appears that the injectivity is generally decreasing with injection. This likely indicates damage to the near wellbore region or an increase in resistance in the reservoir.



It should be noted that both of these Hall plots are using surface pressures, when bottom hole pressures should be used for the calculations. I will go through to recalculate the Hall plot with corrected pressure values in the near future.

To answer your questions, I believe that the Hall plot likely shows that the formation is damaged rather than fractured, but I don't believe that the Hall Plot should be used to determine the MASIP.

On a side note, the step-rate test does show that a fracture was potentially opened at about 3500 psi (BHP), but the changes in injection rate were excessive in this determination. Is there pressure data available for the step rate test that can be used to create log-log plots? In addition to this, is the data available for their falloff test? The falloff test analysis that was provided was inadequate to determine permeability and the skin, but it did appear to indicate partial penetration after the wellbore storage.

If you would like to schedule a call to discuss this, please let me know.

Best regards,

Matthew Liu

Physical Scientist
US EPA Region 6 Office
Ground Water/UIC Section

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